Geochemistry of the Anialik River Igneous complex, N.W.T.

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1 map, 1 overlay and text

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GEOCHEMISTRY OF THE ANIALIK RIVER IGNEOUS COMPLEX

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This report summarizes the results of the first detailed and integrated, petrographic and systematic Au and major element geochemical study of rocks from the Anialik River Igneous Complex (ARIC).

Overview

The ARIC is located about 600 km north of Yellowknife. Detailed geological mapping in the summers of 1987-89 show that the northwestern segment of the ARIC comprises three major, distinct, plutonic phases. The predominant phase is a leucocratic, heterogeneously deformed hornblende-biotite tonalite with subordinate trondhjemite, granodiorite and mafic phases. A previously unrecognized, relatively undeformed leucotonalite phase forms a small but significant body within the predominant tonalite of the complex and a mafic marginal phase comprising heterogeneously deformed diorite and gabbro, forms the western margin of the ARIC; all three phases are intruded by granitic dykes (Abraham and Spooner, 1988; Abraham, 1989). Recent U-Pb geochronology (Abraham et al., 1990, 1991) has corroborated field evidence that the northwestern ARIC is comprised of three distinct phases and indicates that they were intruded over a period of at least 20 Ma. Diorite from the mafic marginal phase (MMP) of the ARIC gives a zircon age of 2703 ±2 Ma; zircon ages of 2694 ±2 Ma and 2682 ±2 Ma were determined on the deformed and undeformed tonalite phases. The much younger age obtained for the less deformed tonalite substantiates the field observations and the U-Pb dating has provided significant age constraints for the geochemical program.

Objectives

The main objective of the proposed geochemical study is to classify the mapped units in the ARIC and attempt to corroborate their subdivision on field and petrographic criteria.

Sample collection

Over 600 samples from the ARIC were collected in the summers of 1987, 1988 and 1989. These samples provided a comprehensive suite of the major and minor lithologies, mineralized samples and those to be used for microstructural and geochronological studies. A total of 47 samples (See Table 1) have been selected as being representative of the major rock units present in the northwestern ARIC, as deduced from field mapping and detailed thin section petrographic analyses (39 samples in 1990). The sample locations are given in the accompanying mylar overlay to previous maps submitted to INAC Geology, Yellowknife.

Sample preparation

The samples chosen were the least altered so as to enable a lithogeochemical rather than alteration-mineralization geochemical study to be carried out. Samples selected from the ARIC suite weighed between 0.5 and 2 kg after removing altered material, the coarse grained plutonic rock samples being larger to ensure homogeneity. The samples were crushed in a steel jaw crusher to approximately 0.5 cm diameter chips which were then split by hand to yield ~100 g of material for pulverization. Rock chips were pulverized in an alumina mill at the University of Toronto to a size of <200 mesh (<75 microns). Splits from the same powder will be used for all major, XRF, and INAA (Instrument Neutron Activation Analysis) analyses.

TABLE 1. GEOCHEMISTRY SAMPLES.

A total of 47 samples from the ARIC were analyzed. Thin section : indicates thin section to be made

Gabbros, mafic marginal phase and sheeted zone (from units 14, 15, 16 and 18).

66 Thin section.
692 Thin section.
696 Thin section.
773 Thin section
769 Thin section
813b Thin section.

Diorites, mafic marginal phase and from within the batholith (from units 19 and 21).

747 Thin section
802 Thin section
805
806 Thin section (sphene geochron).
719 Thin section (geochron sample of xenolith in unit 21tonalite).

Quartz-diorite/tonalites, (from within unit 21).

175 Thin section.
474 Thin section.
477 Thin section.
639 Thin section

Mixed Zone diorites/quartz-diorites,.(from within the area marked 19,21 between Tognazzini and Markham Lakes).

666 Thin section.
753 Thin section.
755 Thin section.
801 Thin section.

Tonalites, (from units 21 and 14)

378 Thin section.
462 Thin section.
478 Thin section.
656 Thin section.
681 Thin section.

Tonalite-Trondhjemite-Granodiorites,.(from within unit 21).

430 Thin section.
598 Thin section.
631 Thin section.
743 Thin section.
757 Thin section.

Tonalite, (unit 20).

720 Geochron sample.
602
604 Thin section.
605 Thin section.

Intermediate (microtonalites) dykes. (from within unit 21)

GC1 Geochron sample.
479 Thin section.
600
640 Thin section.

Gabbro dykes. (from within unit 21).

421 Thin section.
476 Thin section.
497 Thin section.
573 Thin section.

Felsic dykes in the ARIC.

463
494 Thin section.
601 Thin section.
739
754
803 Thin section.

Major Element Analyses

High quality XRF (fusion) major element analyses (SiO_2, Al_2O_3, CaO, Fe_2O_3, MnO, P_2O_5, MgO, Na_2O, K_2O, TiO_2, and LOI) for this study were done by Activation Laboratories Ltd. The standard UTB 1 (1/3), which was included to monitor precision and accuracy of measurements. Fire assay-INAA Au analyses on 26 (10g) samples from the ARIC (See Table 2) were also carried out at Activation Laboratories Ltd.

TABLE 2. AU ANALYSES ARIC.

The following 26 (5g) samples (including five duplicates) were also sent to Activation Laboratories Ltd., and are being analyzed for Au (fire assay-INAA; 1 ppb detection limit).

		Au (ppb)
GC1		5
111	double of 430	2
222	double of 463	3
333	double of 604	<2
378		<2
421		<2
430		<2
444	double of 631	3
463		<2
474		<2
477		<2
478		<2
555	double of 754	9
601		<2
604		<2
631		<2
640		<2
656		2
666		<2
692		<2
739		<2
754		17
757		8
773		<2
803		<2
805		<2

Results

The lithological subdivisions based on field and petrographic criteria are generally substantiated by the geochemical data (see Table 3).

The gabbros from the mafic marginal phase have a large variation in Al_2O_3 contents (~13.5-21.5). Three distinct subgroups are identified; 66 and 813b have low Al_2O_3 and SiO_2 contents, 769 and 773 have intermediate Al_2O_3 and SiO_2 contents and sample 692 which has 21.39% Al_2O_3 is probably a plagioclase cumulate.

The MMP diorites, those from units 19 and 21 and diorites and quartz-diorites from the mixed zone between. Tognazzini and Markham Lakes have relatively high Al_2O_3 (~16.5-18.0%) and intermediate SiO_2 (~52.5-58.0%). Only sample 747 was found to fall well outside and is tonalitic in composition.

Whole-Rock Geochemical Analyses ARIC 91

SAMPLE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	K2O	Na2O	P2O5	LC	TOTAL
66	49.45	1.32	14 02	15.18	0 21	6.33	9.73	0.37	2.00	0.10	1 61	100 39
692	49 40	0.23	21.39	4 83	0 07	6.01	11 74	0.45	2 62	0 03	2.66	99 45
696	52.60	0 68	17 07	8.13	0.13	5.58	9.34	0 84	3.98	0.36	1 29	100 00
773	50.15	0 32	16.36	8.12	0 13	7.73	10.49	1.03	2.74	0.03	2.67	99 77
769	47 26	1.63	15 91	15 31	0.14	4 95	9.98	0.58	2.66	0 03	1.70	1 0 15
813b	47.95	0 57	13 64	9.21	0.14	11 12	10.01	1 20	2.30	0.44	2 60	9 18
747	65.07	0.45	16.88	4.73	0 06	1.93	4.18	1.72	4.04	0 05	1 1	9 30
802	58 96	0 89	17 44	8.35	0 12	2.46	6 07	1.48	4.58	0.14	0 9	9 37
805	57 05	0 53	16.97	7.17	0.10	4.31	7.38	1 15	3.78	0 07	1.39	9 88
808	54 07	0.52	17.24	7 47	0.10	5 20	8.75	0.88	4.27	0.11	1 25	99 30
719	52 47	0.42	17 89	7.06	0.10	6.31	10 34	0.71	3.47	0.02	1 29	100 18
175	61.02	0 47	15.02	6 89	0.13	4 24	6.80	1.04	3.91	0.14	0.89	100 5
474	64.16	0.71	15.90	6.07	0.09	1.69	5.12	1.11	4.38	0.17	0.99	100 9
477	60 88	1 12	16.79	7.31	0.11	1.73	4 98	1.79	4.29	0.26	0 99	100 2
639	71 40	0 28	14 99	2.98	0 04	0.82	3.01	1.35	4.40	0.05	1.10	100 4
666	57.63	0.80	16.79	8 20	0.12	3 51	7 07	1.05	3 53	0.04	1.29	100 03
753	56 74	0 26	18 01	5.72	0.10	4 83	6.73	1 94	3.14	0.02	1.99	99 18
755	55 74	0 90	17.14	8.04	0.12	4.65	7.37	1.55	3.50	0.23	1.00	100 24
801	58 08	0.55	16.90	7.30	0.11	4.46	7.19	1.33	3.83	0.11	0.90	100 5
378	67.23	0.35	15.53	3 63	0.06	1.75	3.11	2.59	3.87	0.07	1.29	99.48
462	67 98	0.33	16 21	3 58	0.06	1.07	3.40	1.65	5.02	0.08	1.09	100.47
478	68 65	0 36	15.19	3.71	0.06	1 25	3.49	1.33	4.38	0.05	0.89	99.36
656	67 77	0.37	15.47	3.90	0.06	1.89	3.40	2.16	4.11	0 08	1.00	100 21
681	67.36	0.51	15.07	4 55	0.06	1.36	3.40	1.63	4.35	0.14	0.79	99 22
430	69 83	0 28	15 29	2.76	0.05	0.94	2.88	1.45	4.68	0.05	0.79	99 00
598	68 55	0.28	15.47	3 23	0 06	1.18	2.80	2.28	4 43	0 07	1.00	99 35
631	70.36	0 33	15.16	2 85	0 04	0.87	2.50	2.25	4.24	0.07	1.10	99.77
743	68 02	0 51	15 12	4 40	0.10	1.74	2.37	2.39	3.88	0.10	1.59	100 22
757	65 58	0 42	15 60	4.90	0 08	1.74	4.15	1 24	4 40	0.10	0.99	99 20
720	55.74	0.13	18.54	8.75	0.12	4.58	8.40	0 98	2.84	0.03	1.49	99 60
602	58 97	0 17	16 86	6.23	0.11	4 08	7.25	1.80	3.23	0.04	1 88	100 62
604	57 92	0.15	17.81	6.85	0.11	4 35	7.11	1.14	3.16	0.02	1 49	100.10
605	55 32	0.13	18 92	6.23	0.11	4.08	7.93	1.48	3.30	0.02	2.69	100.19
GC-1	60 59	0.59	17 23	6.36	0.10	2.52	5 59	1.49	3.61	0 06	1.89	100 02
479	70 61	0 32	15 30	3 27	0.05	0.97	3 59	0.96	4.64	0 07	0.40	100 18
600	61 73	0.55	17.15	6.26	0 09	2.28	5.47	1.45	3.81	0 05	1.30	100.14
640	58 93	0 69	16 44	6 88	0.10	3.40	6.29	1.43	3.37	0.09	1 49	99.11
421	46 27	1 20	13 79	14 36	0.17	7 96	8 09	0 43	2.56	0 09	6 84	99.76
476	49 21	1.30	13 97	15 07	0 20	6 41	10.07	0 38	1.91	0.08	0 99	99 59
497	49 20	1 46	13 70	14 14	0.24	6.54	10 64	0 53	2.23	0.10	1 09	99 87
673	49 43	1.29	14 20	15 08	0 20	6.50	9.84	0.51	1.77	0.09	1.68	100 59
483	74 79	0 01	13 99	0.45	0.01	0.01	0.79	5.00	4.10	0.01	0 20	99 33
494	75 20	0 01	14 03	0.55	0 01	0.08	0.78	4 97	3 98	0.10	0.30	99 98
601	73 92	0 09	14 24	1.31	0.02	0.27	1 83	1.80	5.02	0.01	0.60	99 10
739	74 60	0 02	13 88	1 05	0 03	0 20	0.79	4.00	4.38	0.01	0.20	99 15
754	73 26	0.15	13 99	1 79	0 02	0.62	0.62	1.16	6.42	0.04	1 00	99 07
803	71 57	0.18	15.34	1 88	0.03	0.79	3 50	1.41	4 44	0.06	0 80	100 00

Rocks of the group quartz-diorite to tonalite from within unit 21 span a large range in SiO_2 (~61-72%). Samples 175 and 474 appear to be closer in composition to quartz-diorites, sample 477 falls within the tonalite compositional field and sample 639 which has a SiO_2 content of 71.4% has a granodioritic composition. All four samples show the heterogeneous nature of ARIC lithologies.
Tonalite samples 378, 462, 478, 656 and 681 have a narrow range in SiO_2 (~67-69%). Samples grouped as tonalites-trondhjemites-granodiorites from within unit 21 show a range of SiO_2 values corresponding to these compositions (65.58-70.36%).
There is a clear chemical distinction between the younger unit 20 tonalite and the older unit 21 lithologies. Samples 720, 602, 604 and 605 have a dioritic SiO_2 range (55-58%) and the high Al_2O_3 content (17.81-18.92%) indicates that this unit is a cumulate.
The intermediate dykes, samples 640, GC1 and 600 have narrow ranges in SiO_2 (59-62%) and Al_2O_3 (~16-17.5%). Sample 479 with a SiO2 content of 70.61% appears to be part of a chemically distinct phase of dykes.
The gabbro dykes are similar in composition to sample 66 and all have moderately low SiO_2.
The high LOI for sample 421 (6.84%) corresponds to its highly altered state.
All the felsic dykes except sample 803 have a narrow range in SiO_2 and Al_2O_3 values (~73-76% and ~13.5-14.5% respectively). Sample 803 was originally classified in the field as a leucotonalite to granodiorite dyke has lower SiO_2 and K_2O, and higher Al_2O_3 than the other felsic dykes.
As yet no geochemical evidence has been observed to establish a coherent link between the three major phases of the ARIC and the granitic dykes, but additional interpretation is currently in progress.

A combination of detailed petrography with major element geochemistry indicates that the ARIC is geochemically typical of Archean TTG (Tonalite-Trondhjemite-Granodiorite) intrusive suites, and the data trends obtained are comparable with trends for Archean TTG rocks from the Superior Province and Archean TTG's worldwide (O'Nions and Pankhurst, 1974; Arth et al., 1978; Barker, 1979; Jahn et al., 1981; Martin et al., 1983).

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